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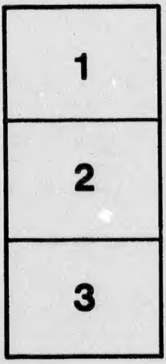

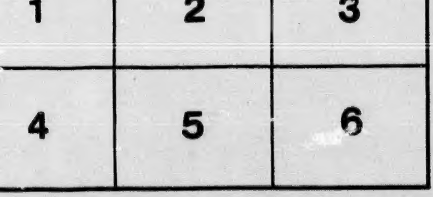

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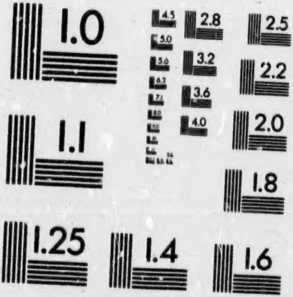

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REPORT

ON

Storage Battery and Overhead Wire Systems

OF

Electric Street Railways

FOR THE

CITY OF WINNIPEG,

BY

H. N. RUTTAN, M. Inst. C. E., M. Can. Soc. C. E.,
CITY ENGINEER.

PRINTED BY ORDER OF THE COUNCIL.

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CITY ENGINEER'S OFFICE,

WINNIPEG, MAN., 4th JULY, 1891.

His Worship, the Mayor, and Council of the City of Winnipeg:

GENTLEMEN,—I have the honor to submit herewith my report on Electric Railways.

The report has been compiled from information obtained during visits to Minneapolis, St. Paul, Dubuque; Chicago, Washington, Philadelphia, New York, Boston, Lynn, Montreal, Ottawa and Toronto.

My observations were chiefly directed to the "overhead trolly" and "storage battery" systems as those which would probably be most suitable for Winnipeg.

Statements of the cost of construction, operation and maintenance of both systems are given. These estimates do not pretend to absolute accuracy for any particular place or set of conditions. It will be understood that they are intended to show a comparison of the two systems only. The questions of the values of street railway franchises is one which it is most difficult to show by any set of figures or comparative statements. The values of franchises depend as much upon the enterprise and good management of the street railway companies as they do upon local conditions, population, grades, climate, etc.

Some instances might be given of railways in cities of large and dense population which are not doing one quarter of the business of railways similarly situated in other places.

My thanks are due to the officers and engineers of the several cities, electric railway and manufacturing companies, from whom I experienced the greatest kindness, and secured most valuable assistance and information, including documents and records which have been of great service to me.

Your obedient servant,

H. N. RUTTAN,
City Engineer.

Overhead System and Tracks.

In Minneapolis the general practice is to place poles in the centre of the street between tracks, which are from 3½ to 4 feet apart. On narrow streets this has the effect of driving the vehicle traffic to the sides of the street, as the centre cannot be used on account of the poles; on many streets there is barely room for a wagon to pass between the car and the curbstone. If street railway traffic goes on increasing in Minneapolis as it has done in the past year, it will be in a short time dangerous or quite impossible to use ordinary vehicles on some of the streets. In Boston, where the wiring is done from the sides of the street, even in the case of long spans, the overhead system appears much less objectionable.

There is no good reason why telegraph and telephone poles, where in suitable positions, should not be used to support the cross-wires of the overhead system. They are so used in Ottawa, where it has been found that very few extra poles are necessary.

In cases where the streets are not very far apart, the "loop" system of tracks has many advantages. Single tracks only are necessary; the cars running down one street and up a parallel street. The loops are interwoven like those of a chain—the cars running in one direction on one link, and in the opposite direction on the other—thus giving street car connection in both directions to within at he most one block of every street. This system is used to a great extent in Philadelphia, and for all streets, except the principal business streets, has many advantages over the double track system.

The system of track construction recommended is as follows:

For paved streets a girder rail 6 inches in height, and weighing 70 lbs. per yard.

Ties 7 feet long, 6x6 inches, spaced 30 inch centres, with double tie at joints. Six inches clean gravel or stone ballast under ties, on thoroughly consolidated and drained roadbed.

For unpaved streets a T rail, 4 inches high, of about 50 lbs. per yard, laid on ballasted ties, 2 feet centres, as above, with longitudinal strip 4x6 inches spiked to ties outside of rail, and chamfered one inch on outside; and longitudinal strip 3x4 inches spiked to ties inside rail. Road material to be trimmed up to strip inside and outside of track, T rail to be changed to girder rail when streets are paved.

It has been a common practice to use girder rails of lighter sections than that above specified, and to raise them above the ties by chairs spiked to the ties.

Mechanically the chair track is objectionable, the side leverage on the rails having a tendency to loosen the rail seat and chair spikes, and the track is expensive to lay, as well as to maintain, on account of the large number of pieces which have to be handled and accurately fitted.

In Washington a girder rail of the flange groove section is used. This rail has the disadvantages of binding on the wheel flanges and wearing them on the insides, sometimes chipping or breaking them, making the traction more severe, particularly on curves, and in a cold climate the grooves are not easily cleared of ice and snow.

On the asphalt pavement in Washington this rail is laid on a longitudinal bed of concrete, and bedded in the pavement material which is brought into contact with it on both sides.

Dubuque Street Railway.

The Dubuque Street Railway Co., of which Mr. J. A. Rhomberg is president, placed a trial car of the Electro Dynamic Co., (known as the "Edco," from the initial letters of its name), on their line in August, 1890. Mr. Rhomberg was so satisfied with the working of the trial car that he has concluded an arrangement with the Edco Co. to equip his line with storage battery cars. At the date of my visit to Dubuque, 25th May, 1891, four of the new cars were in operation, and others were being got ready. It is expected that 15 cars will be in operation this fall. Both the railway company and the public appear to be satisfied with the operation of the storage battery system.

The heaviest grade on the line is about four (4) per cent. The loaded cars experience no difficulty in surmounting it.

The cars run smoothly and make no more noise than an ordinary vehicle on a paved street. The freedom from noise is, of course, due to the form of motor used.

The Dubuque Installation may be considered one of the most perfect storage street railway systems now in use, an extended description of the details of the system may, therefore, be of interest.

The cars are 14 feet in length, and seat comfortably 22 people. They are fitted with two 15 H. P. motors each.

The storage battery equipment for each car consists of two sets of 80 cells, one of which is being charged while the other is in use on the car. Each set of batteries is carried in two iron boxes or trays, containing 40 cells each, which are placed under the car seats. The batteries which are being charged are placed on a platform, level with the car floor. A travelling truck is used in transferring the battery trays between the platform and the cars. The battery trays are provided with racks which are worked by pinions on the cars, truck, and charging table. One man handles with ease a battery tray weighing between 1600 and 1700 pounds. Two minutes is allowed for changing the batteries, though the change can be made in less time.

All electrical connections are made automatically, both in cars and on charging table.

Photographs of the car and transfer truck are enclosed. Two of the battery trays are shown in position on the truck.

Electrical equipment data: 1 generator, 50,000 watts capacity; E. M. F. 250 volts, intended to run six cars.

Storage battery: 2 sets of 80 cells each, per car; weight of cells each, 40 lbs., cells said to have a capacity of 180 ampere hours.

Batteries are changed every three hours, in which time cars run 21 miles.

Record of running four cars on 24th May, 1891:

Average E. M. F. of batteries coming in, 160 volts.

Average E. M. F. of batteries going out, 175 volts.

Average time taken to charge each battery of eighty cells, two hours.

As a rule E. M. F. is not allowed to go below 160 volts, two volts per cell, though it is stated that it may safely run down to 144 volts. It appears, therefore, that about 50 per cent. of the storage capacity of the battery is reserved as a margin of safety.

The rails used for the line are about 52 lb. girder rails.

WASHINGTON.

Two Edco storage battery cars have been running for about four months on the lines of the Washington Street Railway Co.

A contract has been made with the Electro-Dynamic Co. to supply six more cars, which are now being manufactured by the J. G. Brill Car Company, Philadelphia.

It is stated that there is a guarantee for three years that the operation of these cars will not exceed, in cost, that of the overhead system in the same place.

A failure of the batteries took place once, about five weeks after the first cars were placed on the line. The Edco Co. claim that the failure was due to accident or improper usage. No trouble has been experienced since, though the arrangements for charging and changing the batteries are imperfect.

The charging is done from the wires of the overhead system, using a resistance to get the required E. M. F. The batteries are changed at the sides of the car. The new equipment is to be simitar, with the exception of the size of the cars, to that described for Dubuque.

Mr. C. O. Mailloux, consulting engineer of 32 Liberty St., New York, states that a plant to cost $500,000 has been arranged for and is now being installed by him for another Washington company.

In Washington both the overhead and storage systems are used by the same Co., the storage being used on certain streets where overhead wires have been prohibited.

PHILADELPHIA.

The street railways in this city are operated by cable or animal power. Up to the present time the city authorities have refused to permit the erection of the overhead system.

NEW YORK.

The Julian storage battery cars which were run for some time on Fourth Avenue, New York, were taken off on account of a lawsuit and injunction obtained by the Electro-Dynamic Co. for an alleged infringement of the Faure patents, held by the latter company, on storage batteries. It was learned that the cars referred to were exhibition cars, used for the purpose of advertising the system, and were run at a great disadvantage, being obliged to run on the same tracks as, and between the horse cars, and subject to all the delays and stoppages unavoidable in the locality.

There are no electric railways of any kind in New York at present.

Boston.

The only electric railway in Boston is that of the West End Street Railway Co., who use the Thomson-Houston overhead system.

This company is gradually changing from horses to electricity, and has many points of interest as a typical street railway of the old style in process of being modernized ; the wonderful exhibit which it makes of the increase in traffic resulting from the change to electricity, and of its ability to fully meet requirements of excessive traffic, and to continue running without interruption during unfavorable weather and heavy snow storms, are sufficient guarantees that both in economy and efficiency electricity is much superior to animal traction.

Reports had been circulated to the effect that the electric system was not approved by the citizens, and that several people had been killed by the electricity.

Upon enquiry from the superintendent of streets, and the officials of the Thomson-Houston Co. it was learned that no deaths had resulted from electrical accident; but that those referred to were caused by collisions, run overs and such like accidents which are liable to occur with any system of rapid transit.

The following letter from the Superintendent of Streets to Mr. Arthur W. Jones of the Thomson-Houston International Electric Co. is conclusive as to the opinion of the civic authorities :

Boston, November 24, 1890.

Dear Sir,—I am pleased to state that the electric system as used in this city as motive power in the West End Street Railway service, has given satisfaction to the public. Its advantages over the use of horses are, first, greater speed, possibly attended with a slight increase in the element of danger to pedestrians and vehicles ; second, greater cleanliness, due to the entire absence of horses and their droppings.

From my observations of its working thus far, I think it has come to stay, and the travelling public would not consent to a return of the old system.

Very truly yours,
(Signed) J. Edwin Jones,
Superintendent of Streets.

The following table shows the number of cars and mileage of the West End railway for the dates given :

Date.	No. of Motor Cars.	Motor Cars including Towed Cars. Mileage.
Feb., 1889.	9	15,186
March, "	9	36,088
April, "	8	36,829
May, "	9	39,331
June, "	9	38,338
July, "	10	69,238
August, "	13	74,550
Sept., "	31	123,040
Oct., "	31	104,328
Nov., "	38	139,314
Dec., "	68	199,551
Jany., 1890.	84	217,021
Feb., "	130	247,679
March, "	130	254,492
April, "	130	272,914
May, "	201	331,733
June, "	255	351,906
July, "	270	389,695
August, "	308	384,749
Sept., "	312	418,414
Oct., "	288	407,462
Nov., "	287	404,028

Dec., 1890.	282	402,204
Jany., 1891.	282	386,598
Feb., "	282	363,315
At the present time, over	300	

Snow.

In reference to the ability of electric railways to continue operations during heavy snow storms:

On the 2nd March, last, a severe storm, with a snow fall of about 18 inches, occurred in Boston. The newspapers of that date bear testimony to the efficient manner in which the West End Street Railway worked during the storm.

The president of the company, Mr. Whitney, writes to the Thomson-Houston Co., as follows:

"I think the Thomson-Houston Co., and the West End St. Ry. Co., have good reasons to congratulate themselves on the splendid performance of the electric cars, plows and scrapers, during the snow storm of March 4th.

"This was by far the heaviest fall of snow we have had since we have used electricity as a motive power, and, I am told, the heaviest for several years. The whole system was operated without a hitch; this fact speaks for itself.

"There is no doubt but that, with sufficient power, the electric system we are using would operate successfully through the worst snow storms of our climate."

As shown by the daily reports of the West End Street Railway Company, of cars in the house at six o'clock, on March 3rd, after 20 hours of storm, no cars had been retired for electrical troubles; on March 4th, the severest day, only two cars were in the house for electric troubles at six o'clock; and on March 5th, only one car.

Value of Street Railway Franchises.

The following is a synopsis of the conditions upon which the City of Toronto received tenders for the purchase and operation of their street railway system:

It will be remembered that the city took over the system from the company who had been operating it, paying the company an amount fixed by arbitration, viz.: $1,453,788.

The party whose tender is accepted must take over all the property acquired by the city from the Toronto St. Ry. Co., at the amount of the award of the arbitrators.

The purchaser shall not charge the undertaking with bonds or debentures for a longer period than the term of the contract.

At the termination of the contract the city may take over the real and personal property necessary to be used in working the said railways, price to be fixed by arbitration.

The city will construct, reconstruct and maintain in repair, the street railway portion of the roadways, viz.: For double track, 16 ft. 6 in., and for single track, 8 ft. 3 in., on all streets traversed by the railway system, but not the tracks and substructure required for the said railway.

The purchaser shall pay the city the sum of $800 per annum, per mile of single track (not including turnouts) and shall also pay the city per month, on the first Monday of each month,....per cent. of the gross receipts from passenger fares, freight, etc., and other sources of revenue obtained by operating the said railway.

The purchaser shall maintain all tracks to the satisfaction of the city engineer, and shall renew or replace the same as circumstances may require and as the city engineer may direct. In case of repavement of a street, tracks are to be removed and relaid in accordance with best modern practice.

When the purchaser desires or is required to change any existing track, for the purpose of operating by electricity, the city will lay down a permanent pavement in conjunction therewith, upon the track allowance, as herein defined.

General conditions as to replacing roadbed taken up for repair of track.

The purchaser will be required to establish and lay down new lines, and to extend the track and street car service in such streets as may be from time to time recommended by the city engineer and approved by the council.

Provisions as to connecting with lines outside the municipality, in conformity with foregoing provisions.

In case purchaser fails to construct new lines as above, the privilege of laying down such lines may be granted to any other person or company.

Provisions enabling city to take up and replace track for city purposes.

Privilege hereby granted, subject to all existing rights.

Provisions as to removal of snow and ice from tracks, when it exceeds 6 inches in depth must be carted away.

Electric or other new system of motor, or combined system, approved by the city engineer and confirmed by the council, shall be introduced within one year.

Provisions as to sale of reduced fare tickets.

Provisions as to transfers to be satisfactory to city engineer.

No employee shall be compelled to work more than 10 hours per day, nor more than six days per week, and no adult shall be paid less than 15 cents per hour.

Rights reserved to build elevated or underground railways, and railways on certain streets.

The following table shows the several offers which have been received :

*SCHEDULE 'A.' Synopsis of Results of Analytical Statements Showing Amounts to be Received by City Under Tenders.

Names of Tenders.	Capital $2,000,000. Receipts $750,000 With 80 miles of Track City will Receive	Capital, $3,000,000 Receipts 1,000,000 With 80 miles of Track City will Receive	Capital, $3,000,000 Receipts 1,500,000 With 80 miles of Track City will Receive	Capital, $3,500,000 Receipts 2,000,000 With 100 miles of Track City will Receive
Miller Bros.	$110,725	$142,350	$273,600	$387,850
Kiely, Everett, and Others	117,250	135,000	175,500	237,000
" if bonds guaranteed	122,250	150,000	190,500	257,000
" Alternative No. 2, if no cheap tickets	132,250	155,000	205,500	277,000
" Alternative No. 2, if no cheap tickets and bonds guaranteed	137,250	170,000	220,500	297,000
Kiely, Everett, Alternative No. 3, in lieu of percentage and mileage	136,000	136,000	136,000	136,000
Kiely, Everett, Alternative No. 3, in lieu of percentage and mileage, but bonds guaranteed	141,000	151,000	151,000	156,000
Kiely, Everett, Alternative No. 3, in lieu of percentage and mileage, and without cheap tickets	151,000	151,000	151,000	151,000
Kiely, Everett, Alternative No. 3, in lieu of percentage and without cheap tickets, but with bonds guaranteed	156,000	166,000	166,000	171,000
Kerr, Brock, and others	100,300	130,050	257,550	368,050
" Alternative No. 2, $800 per mile and 60 per cent. of net profits	96,400	117,400	207,400	291,800
Kerr, Brock, Alternative No. 3, $800 per mile, 5 per cent. of gross receipts after deducting am'ts received from sale of tickets at reduced fares & 40 per cent net profits	101,592	123,563	193,563	266,567

* From report of City Engineer, City Solicitor and City Treasurer of Toronto, re tenders received for Street Railway property.

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*B

Synopsis of Analytical Statements, Provision having been made by City for Interest and Sinking Fund upon Permanent Pavements only.

reduced fares & 40 per cent net profits	101,592	123,563	193,563	266,567

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* From report of City Engineer, City Solicitor and City Treasurer of Toronto, re tenders received for Street Railway property.

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*B

Synopsis of Analytical Statements, Provision having been made by City for Interest and Sinking Fund upon Permanent Pavements only.

Names of Tenderers.	Assuming—							
	Capital, $2,000,000 Receipts 750,000 with 80 miles of track		Capital, $3,000,000 Receipts 1,000,000 with 80 miles of track		Capital, $3,000,000 Receipts 1,500,000 with 80 miles of track		Capital, $3,500,000 Receipts 2,000,000 with 100 miles of track	
	City to Provide	Profit to City.	City to Provide	Profit to City.	City to Provide	Profit to City.	City to Provide	Profit to City.
Miller Bros.	$	$14,981	$	$46,606	$	$177,856	$	$267,741
Kiely, Everett, and others		21,506		39,256		79,756		116,891
" if bonds guaranteed.		26,506		54,256		94,756		136,891
" Alternative No. 2, if no cheap tickets		36,506		29,256		109,756		156,891
" Alternative No. 2, if no cheap tickets and bonds guaranteed.		41,506		74,256		124,756		176,891
Riely, Everett, Alternative No. 3, in lieu of percentage and mileage		40,256		40,256		40,256		15,891
Kiely, Everett, Alternative No. 3, in lieu of percentage and mileage, but bonds guaranteed.		45,256		55,256		55,256		35,891
Kiely, Everett, Alternative No. 3, in lieu of percentage and mileage, and without cheap tickets, but with bonds guaranteed		60,256		70,256		70,256		50,891
Kerr, Brock, and others		4,556		34,306		161,806		247,941
" Alternative No. 2, $800 per mile, 60 per cent. of net profits		656		21,656		111,656		171,691
Kerr, Brock, Alternative No. 3, $800 per mile, 5 per cent. of gross receipts after deducting amount received from sale of tickets at reduced fares, and 40 per cent. net profits		5,848		25,819		97,761		146,458

* From report of City Engineer, City Solicitor and City Treasurer of Toronto, re tenders received for Street Railway property.

Schedule "A" gives the gross amounts which the city would receive under the several tenders.

Schedule "B" gives the net amount which the city would receive after providing for the maintenance of the pavement.

Though it is understood that there are some places in the United States where the street railways are required to pay to the city annually a small percentage of their gross earnings, this is not the case in any of the places visited by the undersigned, nor has he, at this date, been able to obtain any definite information in reference to such payments.

There can be no doubt that street railway systems in the large towns, when properly managed, are paying enterprises.

The opinion is now held very generally that enterprises such as street railways, water works, public lighting, etc., which, from their nature, are monopolies, and in which there cannot be general public competition, should be managed by the municipal authorities for the benefit of the general public. The public may receive the benefit either from reduced rates or by applying profits to the reduction of the general taxation.

When the public take the whole risk of such an enterprise and supply the capital to work it, it is right that they should receive the full benefit to be derived from it. On the other hand, if it is decided that it is not advisable to enter into such undertakings as public enterprises, but rather to allow them to be taken up by private companies, then, in dealing with such companies, the fact that they assume all risk and supply the necessary capital should secure for them liberal treatment at the hands of the municipal corporations.

The Toronto franchise is, no doubt, one of the most valuable in Canada, and the competition of companies who propose to take it over, on the terms fixed by the city, has been very keen; notwithstanding the great value of the franchise, it appears from column 1, schedule "B," that the net amount to be realized by the city, under the several tenders, is comparatively small.

In Ottawa, the new street railway company (electric overhead system) which has just gone into operation, agrees to pay to the city the sum of $400 per annum for double track and $300 per annum for single track, in consideration of which the corporation agrees to maintain the streets and bridges.

The arrangement in Winnipeg, under which the company pays the cost of paving and maintaining the portion of the street occupied by its tracks, is more favorable for the corporation.

In Superior, the street railway company pays for the pavement, except where power other than that of animals is used, in which case the company pays only such portion of the cost as is "made extra by reason of such track."

COMPARISON OF THE ELECTRIC OVERHEAD WIRE AND STORAGE BATTERY SYSTEMS.

The following remarks are intended to apply to systems having from 10 to 20 miles of track; using from 15 to 40 cars; having no grades exceeding 4 per 100, and operating in localities where snow fall is not excessive.

(1) *Cost*—

By referring to the estimates, page 21, it will be seen that the cost of the systems has been placed at about the same amount. The engine power provided for the storage system is the same as that for the overhead, though, for several reasons, it is probable that less power will be necessary for the storage system.

(2) *Maintenance*—

Maintenance of the storage batteries has been placed at 40 per cent. per annum, this being the amount which will be guaranteed by two companies, though two other companies will guarantee the maintenance not to exceed [illegible] or 15 per cent.

The poles and wires occupy the same relative position in the overhead system as the batteries in the storage system. When an overhead system is once substantially erected, the cost of maintenance should not exceed 10 per cent. per annum, and for the first few years should be much less than that.

(3) *Operation—*

Taking the average electrical horse power at 10 H. P. per car, and the maximum at 20 H. P. per car, on a 15 car road the total average is 150 H. P., and the total maximum 300 H. P.

By observations taken for the purpose, it has been found that the stopping, starting and changing speed of the cars makes the engine load vary rapidly between the minimum and maximum required.

Where the cars are connected directly with the central power, as in the overhead system, in the case stated above, the engine load may vary in a few moments time from 50 to 100 H. P., in addition to the strain upon the machinery and the consequent increased cost for maintenance, this condition requires that the engines be capable of taking up their maximum load at a moments notice, and this means that the steam pressure must be kept at or near the maximum, or in other words, the coal consumption must be always at its maximum.

On the other hand, the starage cars are independent units, each carrying its quantity of power for a fixed time and using it at the minimum or maximum rate as occasion requires.

The engines at the central station are, therefore, run at a constant rate, which rate is the average and not the maximum necessary to move the cars on the line. Placing the electrical efficiency of the storage battery at 80 per cent. and of the overhead wire at 90 per cent. the following statement will show the difference in power required at the central station.

	Storage.	Overhead.
Average electrical H. P. required at car motors....................	150	150
Maximum in storage battery and overhead wire................	150	300
Loss in batteries and overhead wires when engines are working at maximum	37.5	33
Total E. H. P. required............	187.50	333

The above shows the difference in the systems, supposing the efficiency of the engines, generators and motors to be the same in each case.

In this statement all the cars on both systems are giving the same constant efficiency, in practice this is not always done, the E. H. P. for many overhead lines being not much, if any, above the average power required to move the cars.

Placing the maximum E. H. P. at 15 instead of 20 E. H. P. per car for the overhead system—supposing the cars to run 17 hours per day, with coal at $8 per ton and engine consumption at 3℔ per H. P. hour—this would show a saving in favor of the storage battery of $12.75 per day.

In taking 15 H. P. per car as the maximum for the overhead system, it is evident that at times the individual cars will not be as efficient as those of the storage system, for instance when a number of the cars are started, or have any other heavy work to do at the same time.

It has been seen that for 15 cars and 10 miles of track the cost of storage batteries and overhead wires is about the same, say $25,000 each.

The cost of maintenance of the overhead wires being 10 per cent., and of the storage batteries 40 per cent., the difference in favor of the overhead system per day would be $20.54.

In the case of the storage battery, the extra weight carried by the cars, from 1½ to 2 tons each, should also be taken into consideration.

A road, not too long, with a very heavy traffic affords the best opportunity for economically working the overhead system; and a straggling road, with a comparatively light traffic, affords the most favorable conditions for the storage system.

Winnipeg, at present, more nearly approaches the latter condition.

From the point of view of the street railway companies there does not appear to be much to choose between the two systems, the difference at present being in favor of the overhead system.

From the standpoint of the public, the storage system is to be preferred on account of poles and wires not being required in the street.

While it is not expected that any great inconvenience would be experienced from properly erected poles and wires, their absence is undoubtedly sufficient to turn the scale in favor of the storage system.

It should be remembered that the overhead system has probably reached its maximum efficiency while the storage system, though so nearly approaching the overhead system, has not by any means done so.

H. N. RUTTAN,
City Engineer.

Comparative Cost of Operating Various Street Railways.

	1	2	3	4	5	A	B	C	D	E
Average number of Motor Cars per day	15.18	5.2	6.1	.1	3.26			6	15	15
Average number of Trail Cars per day	10.67	2.2	.1	.71						
Average number of Hours per car per day	14.21	14	14.8	12.5	15.6			17	17	17
Average number of Miles per car per day	116	94.2	90	79	105.5		100	100	102	102
Electro-Motive Force	500		500	500	500					
Average Ampere Readings taken hourly	165.86		52.4	30.7	114					
Average Electrical Horse-Power	114.81		38.34	13.1	62.9			65	163	163
Average Electrical Horse-Power per car	4.57		641	7.7	18.7			11	11	11
Number of Passengers carried per day	12,506	2,200	3,540	470	1,066			2,000	5,000	5,000
Number of Passengers carried per car per day	484	297	578	275	327		346	333	333	333
Cost of Operating per car mile	.0515	.0796	.0829	.1260	.0890	.1816	.1321	.1142	.093	.085
Receipts per car mile	.2101	.1581	.3244	.1720	.1550					
Cost of Operating per car per day	$6 03	$7 50	$7 23	$10 07	$9 38		$13 21	$11 66	$9 50	$8 70
Receipts per car per day	$24 23	$14 86	$28 90	$13 75	$16 35			$16 65	$16 65	$16 65
Cost of carrying each passenger	.012	.025	.012	.036	.026	.0367	.0382	.035		

Columns 1 to 5, Electric Street Railways, Thomson-Houston Overhead System.

Column A, The average from 18 Horse Railways, from U. S. census returns.

Column B, The average from 10 Electric Railways, from U. S. census returns.

Columns C and D, Estimated data for Electric Storage Battery Railway, forty per cent. Battery maintenance; first cost, $12 per cell.

Column E, Estimated data for Electric Storage Battery Railway, forty per cent. Battery maintenance; first cost $8 per cell.

Comparative Cost of Construction, Electric Overhead and Storage Systems for Ten Miles Track and Fifteen Cars.

	Overhead.	Storage
15 Cars complete with Motors and Batteries	$75,000	$99,000
Power Plant	10,000	10,000
Electric Plant	8,000	8,000
Overhead System	25,000	....
Shifting Apparatus	....	2,000
Buildings, Land, etc	12,000	12,000
10 miles Track	70,000	70,000
	$200,000	$201,000

Weight per Horse-Power-Hour of Various Secondary Batteries, by Mr. D. Fitz-Gerald.

Name of Battery.	lbs.	Authority.
Planté	396	Reynier.
Faure	88	Faure.
	165	Sir W. Thompson.
Faure, Old Model.	198	Reynier.
" New Model	134	
	133	Prospectus.
E. P. S. L. Plates	110	Reckengaun.
" S. "	135	Fitz-Gerald.
Reynier Zinc Positive Planté Form.	53.4	R. Taurine.
Lithanode Battery, Old Form	34.5	Fitz-Gerald.
" " 'Union' Cell	31.5	G. Forbes.

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